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Abstract: This paper explores issues that arise in implementing monetary policy under conditions of sustained price stability. We discuss several issues that concern the selection of a central bank's inflation objective: price measurement questions must be recognized in articulating the goals of monetary policy under sustained low inflation, questions about the behavior of other key nominal variables, particularly wages, when price increases are on average about zero, and the possibility of other channels through which conditions of very low inflation change relationships within the real economy. We present a framework for analyzing monetary policy reaction functions that can illuminate the choices facing policy makers in a regime of price stability. The zero lower bound on nominal interest rates is a potential constraint on monetary policy when nominal interest rates are low on average, which will tend to be the case when long-term inflation is low. We summarize the results of research done at the Federal Reserve to clarify these issues for the United States and consider the availability and effectiveness of alternative policy tools when the nominal interest rate is at the zero bound.

Keywords: inflation, interest rate policy, zero lower bound, Taylor rules.

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Introduction

The decade of the 1990s has witnessed a surprising, and most welcome, slowing of inflation in most industrial countries and many developing countries. Average consumer price inflation in the OECD countries has declined from 12-1/2 percent in 1980 to less than two percent in 1998.[1] Along with this price deceleration has come a generally accepted view among policy authorities, and also in academic circles, that the primary responsibility of central banks and monetary policy should be to maintain at least this degree of price stability, if not to reduce inflation even further.

In response to these developments, some debate has emerged about whether conditions of price stability pose special problems for monetary policy. In this paper, we explore some issues that arise with respect to implementing monetary policy under conditions of sustained price stability. In particular, we summarize the analysis undertaken on these issues at the Federal Reserve Board. Before beginning this discussion, we review recent experience and selected historical episodes of price stability in the United States and Japan. Experience with near price stability has been limited, and does not yet provide a basis for reaching definite conclusions about the implications of near price stability for monetary policy.

When the inflation rate is clearly higher than desired, policy makers are primarily concerned with the transition costs of lowering inflation and the speed with which they should seek to accomplish that objective. A considerable literature on these issues exists. In this paper, we will not be addressing the question of transition costs. Rather, we focus on monetary policy under conditions of ongoing price stability. We study the implications of price stability both for the formulation of monetary policy (that is, for setting inflation objectives and choosing a strategy for meeting them), and for the implementation of monetary policy (that is, the use of various tools in carrying out the chosen policy).

We begin by reviewing briefly episodes from historical and current experience to show that under conditions of very low inflation or even deflation, such as during the Great Depression

[1] Annual average; excluding the Czech Republic, Greece, Hungary, Mexico, Poland, and Turkey.

in the United States or Japan now, there can be limits on the ability of monetary policy to restore aggregate demand in response to economic collapse. However, during other episodes, such as the United States in the mid-1950's and in the current period, we have observed price stability or near price stability and continued economic expansion.

We next discuss several issues that concern the selection of the inflation objective. First, there are price measurement questions that have to be recognized in articulating the goals of monetary policy under sustained low inflation. Second, there are questions of the behavior of other key nominal variables, wages in particular, when price increases are on average about zero. If nominal wages behave in an asymmetric fashion and rise in markets when demand is strong but resist declining in those markets where demand is weak, firms will on average face higher labor costs in periods of very low inflation or declining prices. Third, there may be other channels through which conditions of very low inflation change relationships within the real economy. Examples of such channels include factors linking inflation with productivity growth and with the rate of unemployment consistent with stable inflation (the NAIRU).

A major constraint on both the formulation and implementation of monetary policy under conditions of price stability is the "zero bound" on nominal interest rates.[2] Nominal rates cannot fall below zero because cash is an alternative store of value. Cash dominates all other nominal assets in terms of liquidity and other characteristics save one: cash pays no interest. So if any other nominal asset paid a negative interest rate, private agents would refuse to hold that asset until its rate of return rose at least to zero.

The zero lower bound on nominal interest rates is likely to become a constraint on monetary policy when nominal interest rates are low on average, which will tend to be the case when long-term inflation is low. In that case, when confronted with a weakening economy, the central bank may find that even though it has lowered its normal policy rate very close to zero, the economy has not recovered. In order to avoid such an outcome, policy authorities might choose a higher inflation objective so that, on average, nominal interest rates are higher and there is more room to lower interest rates should the need arise. Also, policy makers might alter their policy reaction function when the economy is at or near the target of price stability in contrast to when it is somewhat farther from it.

[2] For simplicity, we assume the lower bound for nominal interest rates is zero. Nominal yields dropped very slightly below zero in the United States during the Great Depression and in Japan recently.

In this paper, we summarize the results of research done at the Federal Reserve to clarify these issues for the United States. We also consider the availability and effectiveness of alternative policy tools when the nominal interest rate tool is at the zero bound constraint. Finally, we present a framework for analyzing monetary policy reaction functions that can illuminate the choices facing policy makers in a regime of price stability.

1. Historical and Current Experience with Price Stability

History offers only limited opportunities to examine industrial countries in an environment of sustained low inflation. Some of those experiences have been quite painful for the countries involved, notably for the United States during its Great Depression and for Japan currently. But for the United States in the 1950s and early 1960s, very low inflation by and of itself did not seem to hinder the conduct of monetary policy. And over recent years, the low inflation in the United States has been associated with strong economic growth and a need to keep short-term real interest rates rather high.

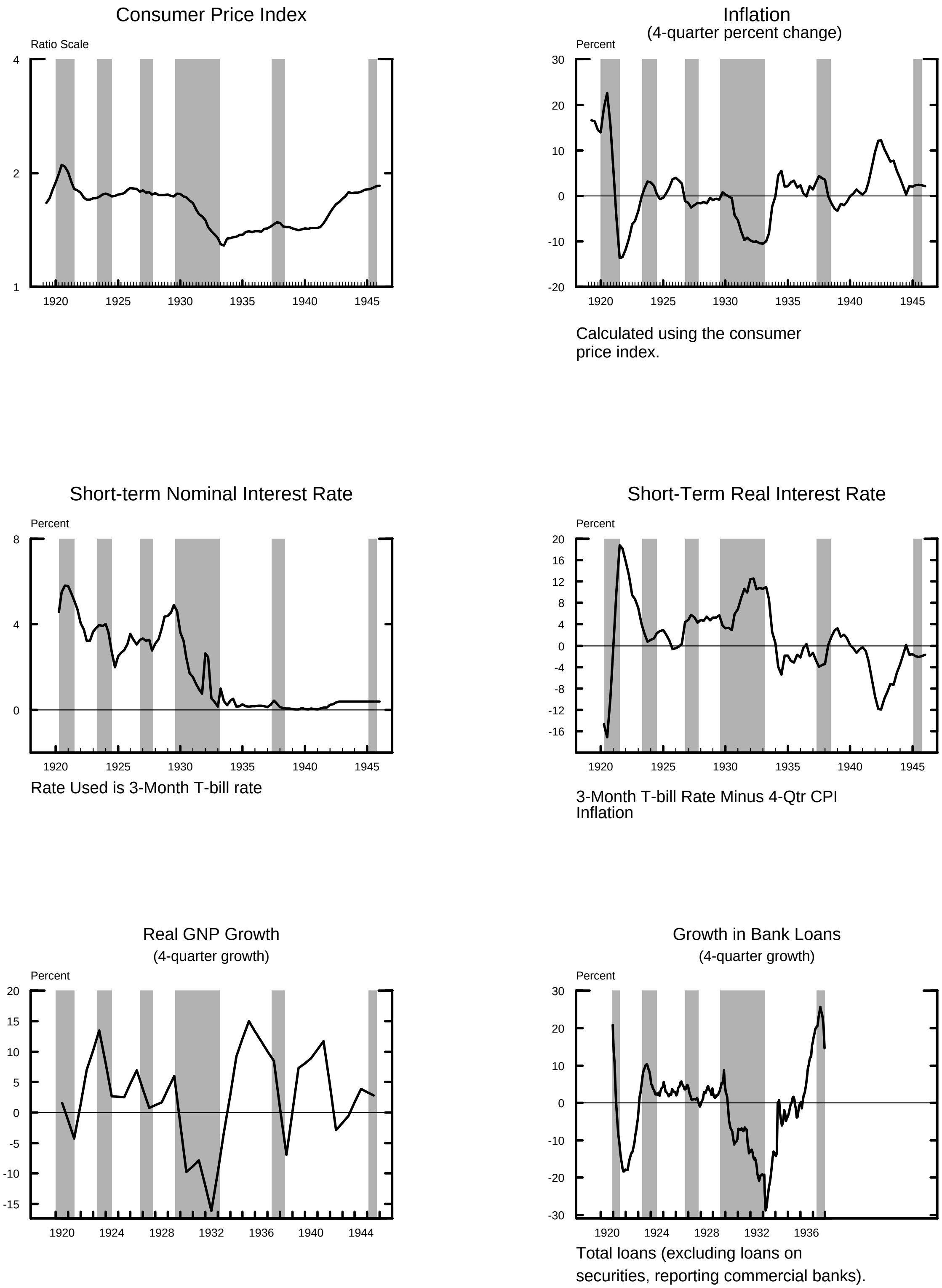
Low inflation and Economic Stagnation

An overview of the performance of the U.S. economy during the period of the Great Depression is provided in Figure 1. As can be seen in the top two panels, the price level in the United States was little changed on net from 1920 to 1945, although the rates of inflation and deflation were quite variable and, presumably, quite unpredictable. As shown by the thickest shaded region in all panels, the Great Depression started in 1929, as dated by the National Bureau of Economic Research (NBER), and continued into 1933. During this period, the Federal Reserve lowered short-term nominal interest rates from about 4 percent in 1929 to virtually zero in 1933, with the short-rate staying at about zero into the 1940s. However, as deflation took hold over this period, estimated short-term real interest rates actually rose through 1933, as shown in the middle right panel.

In retrospect, if the Federal Reserve had lowered nominal interest rates earlier and more aggressively, the deflation of the Great Depression might have been more modest, or perhaps even avoided, because inflation would have been higher and real interest rates lower even though nominal rates were zero. But the Great Depression was also characterized by a banking sector that, at times, was either literally shut down or was open but was contracting loans to businesses and individuals. As shown in the bottom right panel, loan growth at commercial banks was

Figure 1

The U.S. Great Depression



negative for most of the Great Depression and for some time thereafter. This undoubtedly was a drag on aggregate demand and shut down a channel through which monetary policy, in normal times, affects aggregate demand. Reaching the zero bound is almost certainly more problematic in such situations of financial stress than it is when financial intermediaries are healthy.

Stated alternatively in terms of the tools of monetary policy, if the zero bound is a potential problem, the monetary authority would want to monitor the health of financial institutions with extra vigilance and take precautions that it has at its disposal tools that can directly address any problems with intermediaries. Tools such as these were used in the United States in the early 1990s to deal with the problems in the thrift industry. The need for such tools is less pressing when nominal interest rates are positive. At such times, the central bank can boost the values of bank assets, improving the liquidity and solvency of banks, by lowering interest rates.

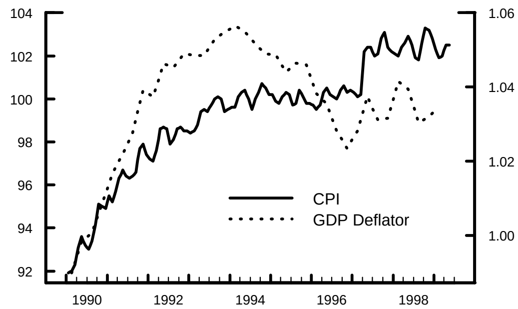
The zero bound has also arguably been a problem recently for Japan, as shown in Figure 2. Japanese economic experience has been strongly influenced by asset price declines and shifts in the stance of fiscal policy over recent years. It is beyond the scope of this paper to consider the impacts of these fiscal measures in particular. But, in the event, monetary policy has apparently been constrained by the zero bound. Short-term interest rates are near zero, as the Bank of Japan's overnight rate has been reduced below five basis points. And as in the United States during the Great Depression, the growth in loans by the banking sector has fallen dramatically, as shown in the bottom right panel of Figure 2.

In this situation, the Bank of Japan has used new tools to try to stimulate private-sector lending. In late 1995, the Bank of Japan implemented repurchase agreements using commercial paper, in an attempt to circumvent the traditional bank-lending channels and provide new funds to the commercial paper market. On average during 1998, the Bank of Japan held, through such repurchase agreements, about one-third of the outstanding stock of commercial paper. In November of 1998, the Bank of Japan expanded its commercial paper activities by extending from 3 months to 1 year the maturity of the commercial paper eligible for repurchase. It also established a temporary lending facility, which was in existence through the first quarter of 1999. This temporary facility made funds available to financial institutions equal to 50 percent of the increase in loans extended by each institution during the fourth quarter of 1998, provided that 50 percent or more of the collateral consisted of private corporations' debt obligations. The Bank of

Figure 2

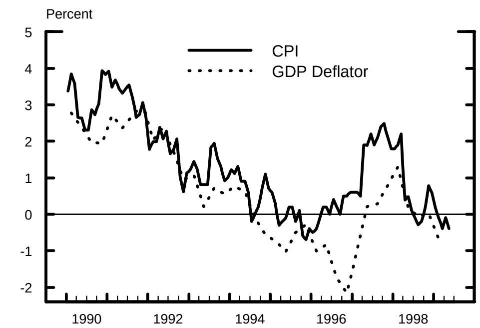
Recent Japanese Economic Performance

Price Level

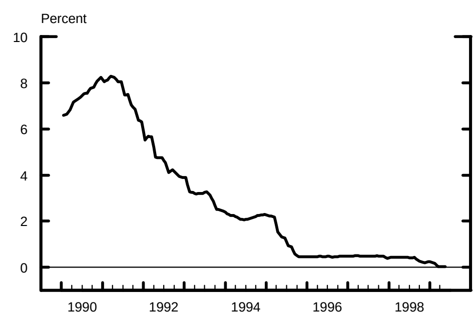


Inflation

(12-month percent change)

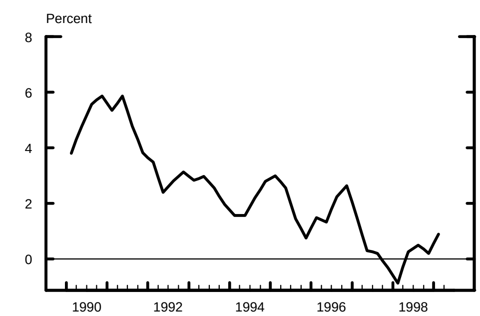


Short-Term Nominal Interest Rate



Rate used above is an overnight rate

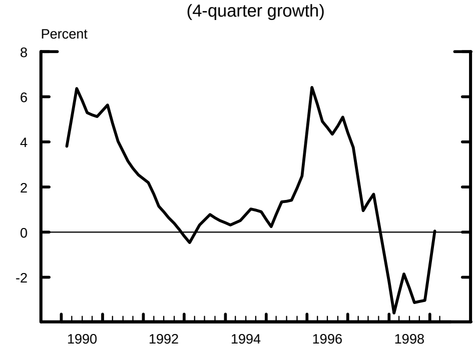
Short-Term Real Interest Rate



Real rate measured as the overnight rate minus 4-Qtr. change in GDP deflator

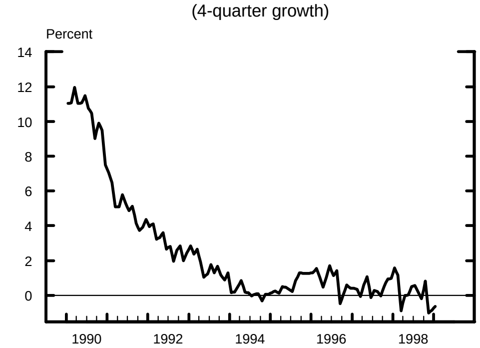
Real GDP Growth

(4-quarter growth)



Growth in Nominal Loans

(4-quarter growth)



Loan and discounts of domestically licensed banks.

Japan has also moved to initiate policy operations in which pools of corporate bonds and loans on deeds would be formed and the BOJ would purchase bills collateralized by such pools.

Although such programs allow the BOJ to enter the corporate debt market, at least indirectly, the BOJ structures these programs so as to limit the corporate default risk it takes on to its balance sheet. In the repurchase operations, the commercial paper must be endorsed by the seller (i.e. by the BOJ's counterparty, typically a bank) and the pools of corporate debt likewise limit the credit risk taken on by the BOJ. To the extent credit spreads are high in such circumstances and the central bank structures its operations so that the credit risk is not transferred to its balance sheet but remains in the private sector, the direct impact of these programs through reducing the cost of funds might be quite limited. However, programs such as these can potentially increase the liquidity of banks and thereby spur lending.

Low Inflation and Good Economic Performance

Although low inflation can bring nominal interest rates close to their lower bound of zero, history provides cases in which low inflation produced no discernable problem for monetary policy and the economies performed very well. One example is the United States economy in the 1950s and early 1960s. As shown in Figure 3, inflation varied between about zero and four percent from 1952 to 1958, but was fairly steady at 1-1/2 percent from 1958 through 1965.[3] Over this period, economic growth averaged about 3-3/4 percent. Even though the U.S. economy experienced three recessions, as defined by the NBER, the zero bound on nominal interest rates was never reached. Indeed, short-term rates tended to move up over the period. As shown in the lower right panel, as the U.S. economy moved into recessions, loan growth at commercial banks slowed. But loan growth stayed positive and rebounded sharply in the economic expansions.

More recently, as shown in Figure 4, the United States has enjoyed another period of low inflation. In the early 1990s, inflation fell to about 3 percent as the U.S. economy suffered a recession associated with financial stress at depository institutions. But more recently, inflation has ebbed to below 2 percent (using the CPI) even as output growth has remained robust. Underlying these developments has been strong growth in productivity which has helped hold down inflation, boosted investment in plant and equipment, and produced gains in equity

[3] The large spike in inflation in 1951-52 is due to the Korean War.

Figure 3

U.S. Economic Performance: 1950-1965

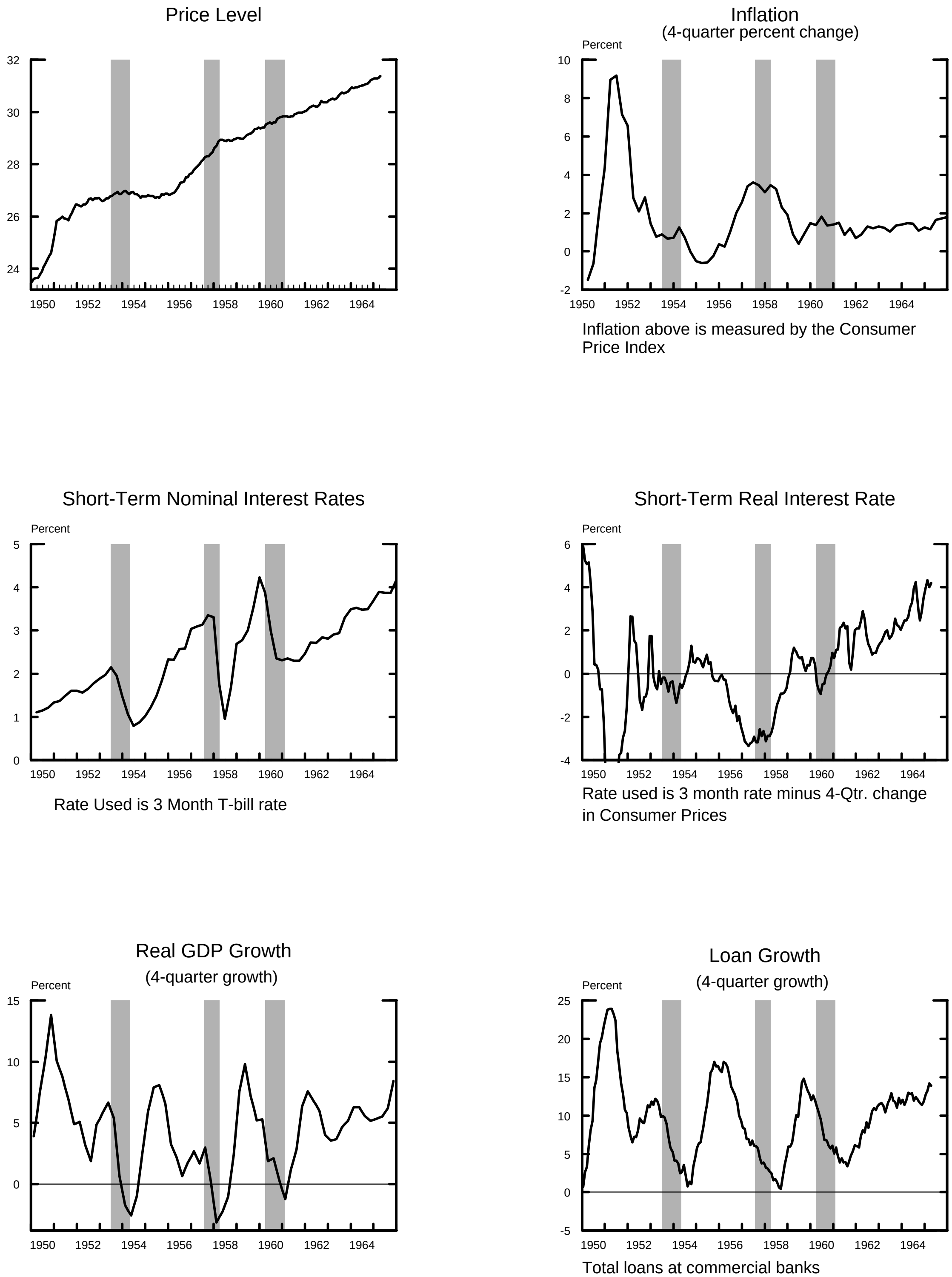
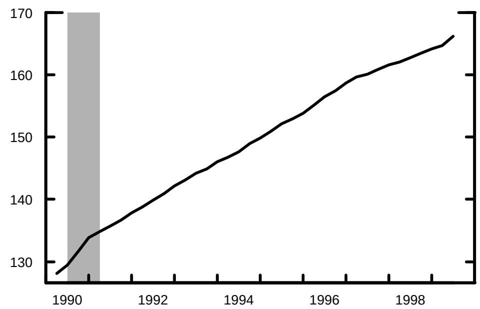


Figure 4

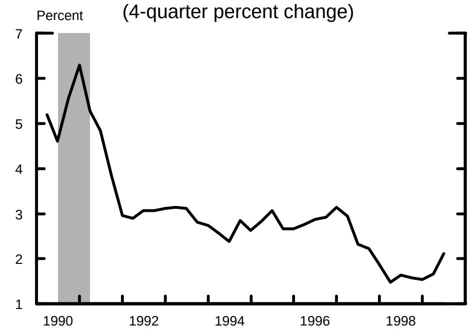
Current U.S. Economic Performance

U.S. Price Level



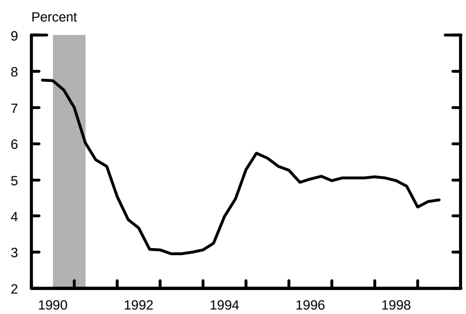
U.S. Inflation

(4-quarter percent change)



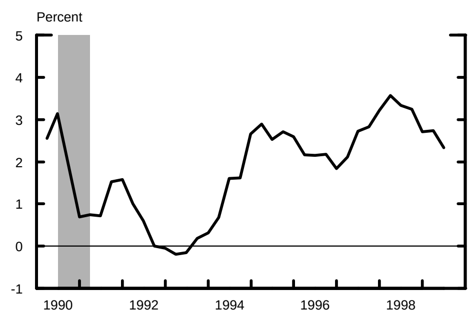
Inflation Above is Measured by the Consumer Price Index

Short-Term Nominal Interest Rates



Rate Used is 3 Month T-bill

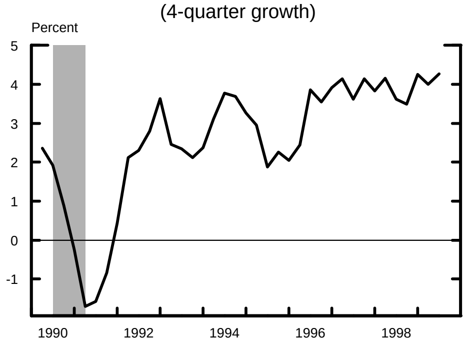
Short-Term Real Interest Rate



Rate Used is 3 month rate minus the 4-Qtr. change in Consumer Prices

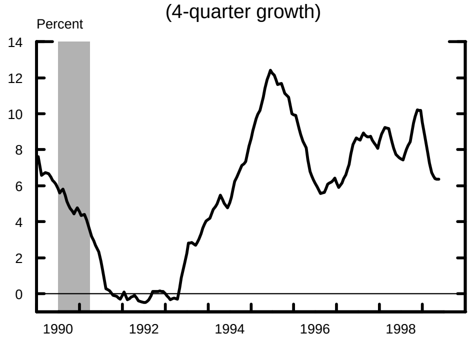
Real GDP Growth

(4-quarter growth)



Loan Growth

(4-quarter growth)



Total loans at commercial banks

markets that have spurred aggregate demand. Financing conditions, as indicated by equity prices and by loan growth (lower right panel), have been generally conducive for growth.

In this economic environment of low inflation, the Federal Reserve has faced no threat from the zero bound. Indeed, while the current nominal federal funds rate of 4-3/4 is toward the lower end of its range since the 1960s, the real Treasury bill rate, as estimated in the middle right panel, is towards its high end, excepting the period during the early 1980s when Federal Reserve policy was restrictive in order to reduce inflation from very high rates. As discussed below, an open question discussed at the Federal Reserve is the extent to which the lower inflation may have contributed to the pickup in productivity growth and the higher equilibrium levels of real interest rates. To the extent lower inflation has such an effect, the zero bound becomes a less pressing problem at low (but not negative) rates of inflation.

These historical experiences may indicate that economies can do quite well at price stability, in particular if they are not hit by downward aggregate demand shocks, although they do suggest that the health of the financial sector may be particularly important should the zero bound be hit.[4] However, this historical review gives little guidance to how low central banks can aim to reduce inflation, and what structural aspects of the economy that the lower limit to inflation depends upon. We now turn to these questions.

2. Selecting Inflation Objectives

Price measurement issues

In order to seek to maintain price stability, policy authorities must form an implicit or explicit notion of what is meant by price stability or the target rate of inflation. This implicit or explicit goal may be a point target, a range, or a ceiling on the rate of price increase; however, the interpretation of price stability as a ceiling raises questions of whether measurable rates of price deflation do not constitute violations of price stability. Clearly for an explicit goal, and even for an implicit goal, it is necessary to confront the measurement problems inherent in the index numbers commonly computed for prices. Those measurement problems include issues of (1) differences in the alternative index numbers that might be used, i.e., questions of composition

[4] Indeed, in Switzerland in the late 1970's, near-zero nominal interest rates coincided with positive economic growth. In this case, expectations of continued exchange appreciation stimulated capital inflows at extremely low interest rates.

and definition and (2) bias in particular measures owing to the techniques used to construct the index.

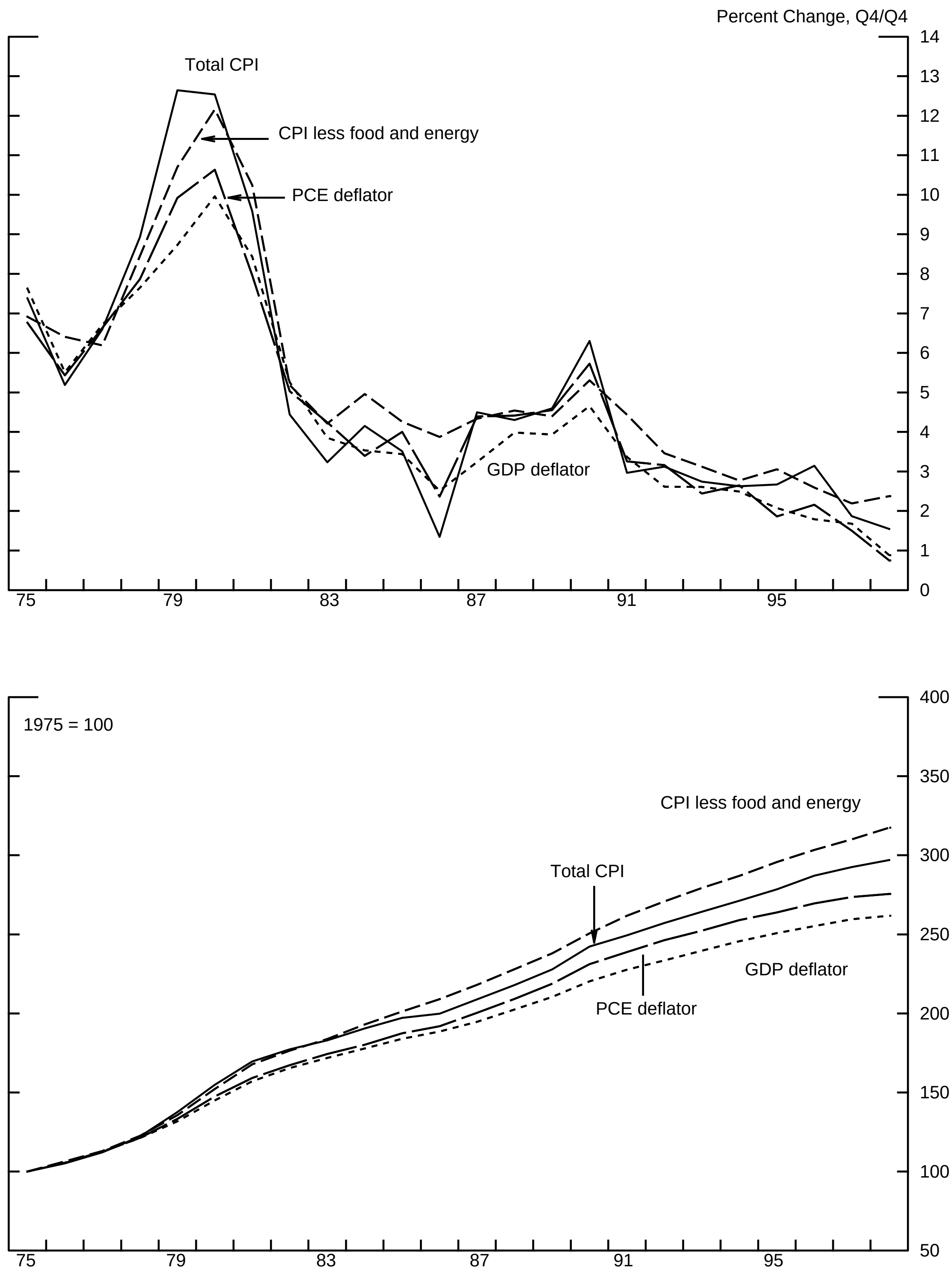
The range of alternative price measures commonly used includes consumer prices, producer or wholesale prices, and deflators from the national income accounts. Because producer or wholesale price indexes normally cover only a limited range of particular goods and no services, these indexes are not suitable as indicators of general price stability. Consumer price indexes are usually fixed-weight index numbers that cover a wide basket of goods and services, typically updated at discrete intervals. Sub-indexes are frequently cited, such as the index excluding energy prices or other volatile price series. Among the deflators, that for personal consumption is an alternative to the consumer price index, with similar coverage. Alternatively, the GDP deflator reflects the mix of production, rather than consumption, within the economy and so effectively excludes prices of imported goods and services. Deflators are typically constructed using a weighting scheme that distorts year to year comparisons.[5] In the United States, the national income accounts have been redefined to be chain-weighted measures, so the deflators are essentially defined as the percent change of each year from the year earlier for an up-to-date set of weights.

When policy makers are seeking to induce significant change, over time, in the inflation rate, the differences at any point in time of these alternative measures is generally not sufficient to be important. But when the goal is to maintain inflation within a fairly narrow range of zero or some low number, these differences can be significant. Figure 5 shows the annual rate of change, fourth quarter to fourth quarter, in four alternative measures of U.S. inflation since 1975. As is evident from the chart, there have been times when inflation, as measured by these indexes, has differed significantly. These episodes include periods of high inflation, such as 1979-80, but they also include an interval such as 1986, when world oil prices fell sharply. As inflation has generally declined in recent years, these measures have been quite close at times, such as in 1994, but less so at others, in 1996 and 1998. More importantly, the consumer price index less food and energy signaled an increase in inflation in 1998 from the rate in 1997 while the other measures recorded a decrease. Using the GDP deflator as the standard, one might plausibly claim that the United States has achieved virtual price stability, with measured inflation recently

[5] Deflators are often constructed as Paasche price indexes that compare a base year to the current year using fixed quantity weights from the current year. While comparison between the base year and any other year in the index is appropriate, comparison of growth rates between adjacent years, for example, is not.

Figure 5

Consumer Price Indexes: United States



under 1 percent, but based on the core CPI, with measured inflation of over 2 percent, there remains work to be done in lowering inflation.

As can be seen in the bottom panel of Figure 5, the alternative index numbers have tended to display consistent differences over time, resulting in evident differences in price level measurement over two or three decades. More important for our purposes, however, is the fact that at near price stability, the differences between the alternative inflation measures, at 1 percentage point or more, are large compared with the measured rate of inflation of 1 to 2 percent. Thus, consideration of which index or indexes to use and how to interpret “price stability” in terms of that index can be important. There is no right or wrong answer to the question of which index to use, but it is important to understand the characteristics of the measure being relied upon to guide policy.

Because the CPI or sub-indexes of the CPI have been quoted in the media and used in various contracts, etc., for cost-of-living adjustments, these indexes have tended to be regarded most frequently as the widely-accepted measure of inflation. For these indexes, in particular, there are serious questions of bias. In the United States, the sources of bias in the measures of consumer prices have been examined closely.

For analytical purposes the bias is thought of as falling into three categories: substitution bias, new product bias, and quality change bias. Substitution bias refers to the fact that with a fixed market basket of goods and services, the index does not allow for substitution by the consumer in response to changes in relative prices. In addition, the index does not take into account the substitution of alternative sources for a good when relative prices at different outlets change. New product bias arises because of the difficulty of introducing new products into the index and capturing their effect on inflation when the basket is updated to include them. Quality change bias results from improvements in the quality of products that are not adequately captured, but instead are recorded as price increases. On balance, these biases lead to an overstatement of inflation by the standard consumer price index.

A study done several years ago of the total bias in the U.S. consumer price index by the Boskin Commission estimated that the bias led to an overstatement of inflation of 1.1 percent per year, with a plausible range around that estimate of 0.8 to 1.6 percent per year.[6] In recent years,

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[6] ***Toward a More Accurate Measure of the Cost of Living***, final report of the Advisory Commission to Study the Consumer Price Index, December 4, 1996 (chaired by Michael Boskin). Estimates of the bias in the U.K. retail price index are provided in ***Measurement Bias in Price Indices: an Application to the UK's RPI***, Alastair W.F.

in response to concerns about the bias as evidenced by this study and others, the U.S. Bureau of Labor Statistics has introduced reforms into the calculation of the Consumer Price Index. Related improvements have been made by the Bureau of Economic Analysis to the indexes in the national income accounts.[7] These methodological changes (some of which are still to be implemented) are estimated to lower measured annual consumer price inflation by nearly 0.7 percentage point and measured inflation of the GDP deflator by almost half that amount.[8] Not all of these improvements can be thought of as reducing the biases discussed above as some of the changes were anticipated in the calculation of the bias. Nonetheless, on balance the bias in the consumer price index and the deflators have been reduced significantly.

In conducting monetary policy under conditions of price stability, it is essential that the policy authority recognize the differences in alternative price indexes and have a reasonable estimate of the extent of bias, if any, in each. Otherwise, there is a risk that too low a target for inflation will be set. If, for example, a target of zero is set for an index with significant positive bias, the monetary authority would, in effect, be imposing deflation on the economy. As a result, distortions such as increases in the real value of nominal debts would occur, thereby creating windfall gains for creditors and losses for debtors.

In general, as long as the imperfections in our various standard measures of inflation are well understood both by the public and by the central bank, it should be possible to formulate monetary policy in terms of one or more of them at times of price stability. If the various agents in the economy are aware of the "true" inflation rate that is relevant for their decisions, they will correctly perceive price stability; and their decisions will not be distorted. However, if some agents respond to a biased measure of inflation as if it were "true" while others do not, distortions could result. Such an outcome might occur if labor market contracts or decisions treat inflation as measured by a given index as "true" inflation when it is in fact biased. Similarly, in assessing various measures of real interest rates, the bias imbedded into the measures of inflation needs to be taken into account. In explaining prospective monetary policy in the semi-annual

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Cunningham, Bank of England Working Paper Series No. 47. That paper reports plausible upper and lower bounds on U.K. bias of 0.35 to 0.8 percentage points per year.

[7] Some of the changes include the use of geometric rather than arithmetic means to reduce substitution bias, improvements in the procedures used to measure health services, improvement in the formula used to calculate increases in rent, and a switch to hedonic price measures for personal computers.

[8] Estimates are taken from Table 2-4 of the ***1999 Economic Report of the President***, page 94.

Humphrey Hawkins Report to Congress, Federal Reserve officials do not set an explicit target or range for any price index. Considerable attention is paid, however, by Federal Reserve officials to the differences in the standard measures of U.S. inflation and to the biases that remain in those measures.

Inflation and real economic behavior

"Price stability" has near-universal acceptance as an appropriate objective of monetary policy, and there is a similarly broad consensus that the monetary authorities should seek to keep inflation rates, properly measured, "low", if not actually at zero. But what are the arguments for choosing among alternative low rates, including zero? In the United States, price inflation as measured by the consumer price index has remained between 1.3 and 2.3 percent (12 month changes) for the past 24 months. Would an even lower rate be better?[9]

One reason why low, but positive, inflation rates may actually help the economy is that positive inflation may make it easier for real wages to adjust downward. If nominal wages are sticky downwards – if workers are particularly resistant to cuts in their nominal, as opposed to real, wages – firms may find it difficult to make changes in real wages. In this case, firms will face higher than optimal wage costs, and sustainable output will be lower as a result. If the central bank were to pick a very low target rate of inflation, rigidities in the economy would emerge that could be avoided at a slightly higher target rate.

It may also be the case that the negative effects of inflation on the economy are lower at lower inflation rates, and therefore the potential gains from reducing inflation further, once it is already below some threshold, are less. (For example, it may be the case that inflation is less variable, and therefore more predictable, at lower rates.) The empirical literature finds only weak evidence, at best, of a negative relationship between inflation and economic growth at very low levels of inflation. As a consequence, central banks may see little gain from risking greater problems from the zero bound constraint by selecting an extremely low target rate of inflation.

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[9] Friedman (1969) argued that in order for an economy to enjoy all the benefits from the transactions "services" of money, central banks should strive for a rate of deflation that keeps nominal interest rates at zero on average, keeping the demand for money high. On the other hand, while positive inflation does impose a burden on society, it also increases government revenue from the inflation tax, or seigniorage. Based on consideration of tax efficiencies, the optimal rate of inflation is the one at which the marginal burden from the "seigniorage tax" equals the marginal burden from other (distortionary) taxes. However, efforts to find empirical implications of this reasoning for the optimal rate of inflation have been inconclusive. In general, neither of these lines of economic theory have had a major impact on policy decisions.

However, some recent evidence suggests that lower inflation is associated with faster productivity growth, even at low inflation rates. This correlation appears most pronounced in recent data for the United States -- it is obviously of interest to see whether it emerges in Europe and other areas as well. Where it holds, this relationship implies an interaction between the target rate of inflation and sustainable growth.

All of these factors are essentially empirical phenomena – some will characterize a particular economy more than others. Their importance for choosing a target rate of inflation will similarly vary across countries. In the remainder of this section we review some of the evidence on the importance of these factors in the United States.

Inflation and real wage adjustment

In his presidential address to the AEA in 1971, James Tobin famously suggested that inflation "greases the wheels" of the labor market, and by implication, argued that some positive rate of inflation was desirable for the economy. A substantial literature has used survey data to address the empirical question of whether wages in the United States do in fact exhibit signs of downward nominal rigidity. The basic approach is to test for truncation in the sample distribution of individuals' wage changes -- most investigators report a significant concentration of nominal wage changes at zero and a significant truncation of the lower (negative) tail, suggesting that nominal wage cuts occur less frequently in the data than they would if they were unconstrained.[10] There has been only limited work on this topic done for countries outside the United States. Because the nominal wage rigidity presumably reflects a variety of cultural and institutional factors, it is hard to say how important this effect might be in other countries.[11]

While most observers agree that there is credible evidence of downward rigidity in US wages, assessing the macroeconomic or welfare implications of this fact is not straightforward. In a recent and influential paper, Akerlof, Dickens, and Perry (1996) use stochastic simulations of a dynamic general equilibrium model to obtain a substantial negative impact on welfare of a reduction in inflation from 3% to 0. This paper makes an important contribution, in that it analyzes downward wage rigidity in a complete macro model, but the model used is highly

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[10] Lebow, Stockton, and Washer (1995) and Akerlof, Dickens, and Perry (1996) both briefly summarize the literature, although they reach different conclusions about the interpretation of the empirical results. A number of methodological issues arise in this work, most notably whether and how to correct for possible measurement error, so the interpretation of the survey results is not unambiguous.

[11] Akerlof, Dickens, and Perry cite some results for Canada and argue that they support the existence of downward rigidities.

abstract and is only loosely calibrated to US data. It is fair to take their results as suggesting that the welfare effects of downward rigidity should not be dismissed out of hand, but they should not be regarded as definitive. Critics have argued, in contrast, that the effects of downward wage rigidity in the United States are too small to be important to the overall economy and that recent experience with low and falling inflation rates in this country has not provided any evidence of the effects of increased wage rigidity. More recent work at the Board by Lebow and others uses a new dataset to obtain results supporting the existence of downward wage rigidity. Other authors have argued that evidence of downward rigidity reflects historical levels of moderate to high inflation, and that in a world that actually achieved near-zero inflation, worker resistance to nominal wage cuts would be reduced.

Inflation and economic growth

There is a substantial literature that uses cross-country data to test for an empirical relationship between inflation and economic growth.[12] Using a simple cross-country "growth regression" framework, in which a country's average growth rate over one or more decades is regressed on average inflation and other explanatory variables, investigators have generally found evidence of a negative relationship between average inflation and real growth rates over the period since 1960. This approach has also been used to identify a negative relationship between the <u>variability</u> of inflation and economic growth: countries with a more variable inflation rate tend to have lower average rates of economic growth. However, because of the high positive correlation between the rate and the variability of inflation, these studies have not been able to demonstrate with any precision that the level of the inflation rate affects economic growth independently from its effect on variability. In other words, simple cross-country growth regressions don't tell us whether high inflation is bad for growth because it is high, or because it is unpredictable. Further, these studies have had only limited success in identifying a nonlinear relationship between inflation and growth – an increase of 1 percentage point in the inflation rate has the same effect on growth whether the inflation rate itself is 0 or 50 percent.

Two Federal Reserve economists, Ruth Judson and Athanasios Orphanides, have adopted another approach in a recent paper to investigate these points.[13] They use a cross-country panel regression of annual data, rather than averages over the entire sample, and they construct intra-

[12] Clark (*Economic Inquiry*, January 1997) provides a survey.

[13] Judson and Orphanides (1999)

year measures of inflation variability using quarterly data for many of the countries in their sample. This approach yields sharper estimates than the basic growth regression approach. The authors are able to identify separate, significantly negative effects of inflation and the variability of inflation on economic growth. These results confirm that lower inflation is good for economic growth, even if the variability of the inflation rate remains the same, and thus reinforce the case for reducing inflation as much as possible, even down to zero.

Judson and Orphanides also obtain good estimates of the concavity of the response of growth to inflation. They allow for a differential response for inflation rates below 10% per year, between 10% and 40%, and above 40%. In these results, the negative relationship between growth and the level of inflation is insignificant, or in some cases reversed entirely, for countries with inflation rates below 10%. In contrast, the negative relationship between the variability of inflation and growth is preserved at low levels of variability of inflation. These results, which are similar to those reported in Sarel (1996), suggest the intuitively appealing conclusion that low levels of inflation do not in fact reduce economic growth, so long as inflation remains predictable. However, they do not directly support the idea that eliminating low levels of inflation helps the economy.

Inflation and increases in productivity

In recent years, the United States has seen low inflation associated with unusually high productivity growth and an apparent downward shift in the NAIRU, the rate of unemployment consistent with stable inflation. This correlation has led some observers to postulate a causal relationship between low inflation and high productivity growth. If such a relationship exists, it would provide a powerful additional motivation for policy-makers to try to bring inflation rates as close to zero as possible.[14] However, while evidence of a statistical relationship linking lower inflation with higher productivity growth is fairly robust, it is more difficult to demonstrate a structural relationship between the two. Rudebusch and Wilcox (1994) present some initial work on this topic, which has been extended in FRB staff work by Berkowitz (1997). There is some evidence that inflation "Granger-causes" productivity growth, meaning that a reduction in inflation in the current period is associated with faster productivity growth in the future, while

[14] It is implicit in our entire discussion that bringing the inflation rate below zero would be undesirable. Negative inflation would in general impose the same types of uncertainties, costs, and distortions on workers, consumers, and firms that positive inflation would; in addition, the effects of the zero lower bound on nominal interest rates would constrain the monetary authorities even more at negative rates of inflation.

the data do not suggest that productivity growth Granger-causes inflation. These results provide some support for the existence of a structural relationship through which lower inflation boosts productivity growth.

One explanation for these empirical results is that common supply shocks, such as commodity price increases, simultaneously affect both inflation and productivity growth, perhaps with different lags. Berkowitz tests for this possibility by estimating a simple macro model for the United States and using the residuals from the estimated equations to represent unanticipated shocks to the economy. He finds that including these shocks in the inflation-productivity regressions does not significantly affect his earlier results, which is consistent with the existence of a causal link from inflation to productivity growth. Berkowitz also looks for evidence that lower inflation raises the return to capital, increasing investment and thus labor productivity, but his results are inconclusive. If a structural relationship between productivity and inflation does hold, it could lessen the potential impact of the zero bound. If lower inflation raises productivity growth and thus raises the equilibrium real interest rate, it thereby raises the equilibrium nominal interest rate for any given rate of inflation and increases the scope for lowering nominal interest rates.

Another interpretation of the negative correlation between inflation and productivity growth in the U.S. data is that both result from structural shifts in the economy, perhaps generated by technological change, that have also led to a fall in the NAIRU. This recent shift emerges from estimated Phillips curve equations linking wage or price growth to unemployment or output gaps. There is clear evidence of a downward shift in the NAIRU at some point in the 1990's, although again, it is difficult to place a structural interpretation on this change.

The evidence linking inflation and productivity growth should be viewed as preliminary – it is based on very recent U.S. data and has not yet been confirmed for other countries. If this result proves to be robust, it would suggest that low inflation does in fact promote economic growth.

4. The Zero Bound on Nominal Interest Rates

The zero bound on nominal interest rates is a feature of any economy in which cash holdings are a medium of exchange, are not taxed, are costless to hold (and insure), and do not pay interest.[15] Phelps (1972), Summers (1991) and Fischer (1996) have argued that the zero bound poses a potentially serious problem for monetary policy. If economic activity is weak or contracting and interest rates hit the zero bound, a dangerous dynamic can be set in motion. Falling inflation, or even escalating deflation, would increase real rates of interest. As this depresses aggregate demand further, downward pressures on prices would raise real interest rates further: The economy would potentially face a downward deflationary spiral.

These authors have conjectured that the likelihood of encountering this problem could be significantly lessened if long-term inflation is not allowed to decline to zero but is kept in a range of one to three percentage points. With a rate of expected inflation of this magnitude built into nominal interest rates, the economy would be entering any potential recession with nominal interest rates that much higher than they would be if long-term inflation was zero--providing more scope for monetary policy to ease by lowering nominal interest rates.

Assessing the degree of risk from hitting the zero bound–and the severity of the consequences–are essentially empirical issues. Detailed empirical studies of the U. S. economy by Fuhrer and Madigan, Orphanides and Wieland, Tetlow and Williams, and Reifschneider and Williams indicate the risk associated with zero inflation may be significant but that an inflation rate of one to three percent is sufficient to alleviate most of that risk.[16] For example, Orphanides and Wieland find that the zero bound on nominal interest rates has a significant detrimental impact on economic performance if policymakers strive to target inflation below 1 percent. Recessions are not only more frequent and last longer, but output is below potential--by the order of 0.1 percentage points on average.[17] Output is at potential, on average, when long-term inflation is high enough to prevent interest rates from ever hitting the zero bound. But when

[15] For simplicity, we assume the lower bound for nominal interest rates is zero. Nominal yields dropped very slightly below zero in the United States in the Great Depression and in Japan recently.

[16] None of these studies incorporate a linkage through which low and stable inflation makes it easier for businesses to plan for the future and thereby boosts long-term investment, productivity and growth. As discussed above, such a causal linkage has not been demonstrated conclusively in empirical studies, but the paths of inflation and productivity growth in the United States during the 1990s are certainly consistent with such a relationship.

[17] Orphanides and Wieland conduct their analysis using a small macro model with rational expectations estimated using quarterly data for the United States.

inflation is so low that the zero bound is reached, the ineffectiveness of policy in stimulating aggregate demand keeps output below potential, on average.

Reifschneider and Williams use the Federal Reserve Board staff's econometric model of the U.S. economy and model the Federal Reserve as setting the short-term interest rate in response to deviations of inflation from a presumed target and of output from potential---the Taylor Rule. They also find that the zero bound becomes important for inflation targets below 1 percent. At an inflation target of zero, they find the policy rate is essentially at the zero bound nearly one-fourth of the time (compared to about 2 percent of the time when inflation averages 3 percent) and the percentage of the time the economy is in a state of low economic activity is 10 percent (versus 2 percent at average inflation of 3 percent).[18]

These studies were all conducted using stochastic simulations of empirical macro models in which the Federal Reserve was assumed to set short-term interest rates in accordance with a fixed policy rule and to have complete credibility with the public that it will continue to follow the rule in the future. Because financial markets are forward-looking in these models, this gives the Federal Reserve a powerful ability to affect longer-term interest rates and thus to stimulate the economy in response to an adverse demand shock. Nonetheless, the zero bound still can significantly handicap monetary policy.

But these studies also make assumptions that potentially limit the effectiveness of monetary policy. First, open market operations are implicitly used to purchase only short-term Treasury debt. And second, the transmission mechanism of monetary policy is solely from short-term rates to longer-term Treasury rates and then to other asset prices and rates of return. The stock of money, and the monetary base in particular, do not play a role in the transmission mechanisms in these models. If there are other effective channels of policy transmission or other effective policy tools not considered, then the zero bound may be less of a problem than envisioned in these studies. Indeed, recent experience in Japan suggests that should an economy become mired at the zero bound, central banks will consider creative new ways to make their policy tools more effective.

[18] A state of low economic activity is defined as a situation in which a two-quarter moving average of the output gap is greater than 6 percent in absolute value.

Alternative Channels for Open Market Operations in Treasury Bills[19]

Direct Effects Through Increases in the Quantity of the Monetary Base

When short-term interest rates are at zero, further open market purchases of Treasury bills cease to have their direct impact on the Treasury bill (T-bill) rate, but continue to increase the stock of the monetary base. The question for policymakers is whether increases in the base brought about in this way are likely to have a stimulative impact on the economy.

When interest rates are positive, the monetary base (and perhaps other forms of money) is a form of liquidity, but T-bills are not--as evident by the interest rate that households forego in order to hold base money rather than T-bills. At a zero rate of interest on T-bills, the monetary base and T-bills essentially are perfect substitutes in household's and firm's portfolios as reflected by their equal (zero) rates of return. Even though open market purchases of T-bills increase the monetary base, an open market operation in two perfect substitutes does not cause households to reconsider either their portfolio allocations or their spending decisions.

From the perspective of financial intermediaries in particular, as part of their portfolio adjustment, intermediaries equate the risk-adjusted marginal returns across the various assets in their portfolios. When Treasury bills and federal funds lent have interest rates of zero, the quantity of loans would be adjusted until their risk-adjusted return also equals that on Treasury bills (namely, zero). Further open market purchases of Treasury bills cannot lower the Treasury bill rate further and therefore do not affect the equilibrium quantity of loans. Open market purchases of Treasury bills would simply boost the level of excess reserves.

Indirect Effects on Expectations

If a central bank were to continue to purchase T-bills even after the interest rate hit zero, the public, upon observing these transactions, could alter its expectations of both future short-term nominal rates and of future inflation. These changed expectations could, in turn, affect current longer-term nominal and real interest rates.

To avoid the potential downside risks associated with the zero bound, Krugman, Mishkin and others have relied on an ability of central banks to increase inflation expectations to help stimulate an economy at the zero bound. For example, in the context of Japan's recent sluggish growth and near-zero short-term interest rates, Krugman has suggested:

[19] This section draws heavily on Clouse et. al.

> "The way to make monetary policy effective, then, is for the central bank to credibly promise to be irresponsible---to make a persuasive case that it will permit inflation to occur, thereby producing the negative real interest rates the countries need."

Likewise, Wolman finds

> "monetary policy can offset the zero bound by generating temporary expected inflation. With real rates thus unconstrained, the existence of the zero bound does not appear to constitute an argument against a low inflation target."

This flexibility in inflation expectations is brought about in part by a Federal Reserve policy rule that targets the level of prices in the long run. As a result, temporary declines in aggregate demand and the price level generate increased expected inflation as the price level returns to target. This inflation is anticipated and lowers ex-ante real interest rates.[20]

So it may be that if a central bank continued open market purchases of Treasury bills, perhaps in massive quantities, there would be a direct effect of increasing inflation expectations. But while this effect is possible, and may be worth trying at least to some degree, it may be somewhat ineffective for two reasons. First, if economic activity is relatively low and unemployment is relatively high, this is likely caused in some considerable part by wages and prices that are sluggish. This sluggishness suggests that expectations of future inflation would incorporate this sluggishness and therefore not rise quickly to lower real interest rates.

Second, for monetary policy to affect expectations of future inflation, market participants must believe that in the future the central bank will have the ability to stimulate aggregate demand and thereby increase inflation. An unfortunate implication of the zero bound is that the worse the current economic downturn, the longer may be the period over which interest rates are expected to remain at zero. In other words, the further out in the future may be those periods in which interest rates are expected to be positive and, therefore, in which the central bank can use its standard tools to stimulate aggregate demand. If so, the central bank has limited ability to increase the public's expectation of inflation and, thereby, lower current real interest rates.

Alternative Policy Tools

In light of these possible limitations to continued open market purchases of T-bills after

[20] Wolman (1998), page 17. Wolman also shows that with policy rules that target the rate of inflation (and not the price level), the zero bound can be an impediment to achieving full employment.

the interest rate has hit zero, a central bank may wish to either replace or reinforce these purchases with other policy actions. Several of these alternatives (purchasing treasury bonds, writing options on interest rates, and purchasing foreign exchange) can be viewed as extensions of conventional open market operations, while others (purchasing private sector securities, discount window lending to the non-bank sector, and direct cash transfers to the public) represent potentially new directions for U.S. monetary policy.

Purchasing Treasury Bonds

Perhaps the most obvious extension of a central bank's policy actions beyond the purchase of T-bills is to engage in the open market purchase of longer-maturity government debt. The effects that such actions can be expected to have on longer-term Treasury rates depend on how one sees interest rates as being determined. Following fairly standard views, we view long-term Treasury rates as composed of expectations of future short-term interest rates and term premiums. To have an impact, open market operations would have to affect at least one of these two components.

It is not clear why purchases of government bonds should affect expectations of short-term interest rates. The current impact on the monetary base is the same whether bonds or bills are purchased. And just because bonds have a longer maturity than bills, it does not follow that the increase in the base from a bond purchase will be sustained over a longer time period than would an increase brought about by a purchase of a T-bill.

Therefore, it would seem, that bond purchases would have to affect interest rates through impacting term premiums. Purchasing bonds, and decreasing the public's holding of bonds, can decrease the term premium if bonds and other assets are imperfect substitutes in the public's portfolio. In order to induce the public to hold fewer bonds, the central bank would bid up the price of those bonds and thereby lower their yield. However, historical evidence, such as Operation Twist in the United States in 1961, does not seem to support this notion of significant interest rate effects stemming from changing the relative supplies of assets. But, it remains an open question as to what the effects would be of truly massive purchases of government bonds. A central bank could presumably overwhelm the markets and raise Treasury bond prices. Indeed, the Federal Reserve fixed the yields on U.S. Treasury securities during and immediately after World War II. Presumably, bond purchases on a large enough scale could drive Treasury bond rates to zero, or nearly so.

Writing Options

With long-term interest rates importantly affected by expectations of future short-term rates, a central bank may find interest rate options a valuable tool for affecting longer-term interest rates. With options, a central bank can convey its intentions regarding the future course of short-term rates. In particular, the central bank could enter options contracts in a way so that if future short-term interest rates rose above a specified level, the central bank would be obligated to make a payment to its counterparty. Not only would this inject reserves when interest rates rose, it would penalize the Federal Reserve for its failure to keep rates low. And the private market would gain financially --- the options would essentially be providing some insurance should short rates rise above the specified levels.

To accomplish these goals, the central bank would be the party to write the option and would set the strike price to correspond to the particular interest rate ceiling (i.e. a specific floor for T-bill prices) it desired to convey to the market. Then, if market rates were to rise above the ceiling rate, the price of the Treasury bill would fall and the holders of the option would have an incentive to exercise the option---purchasing a T-bill at a low price in the market and "putting" it to the central bank at the higher strike price.

Options not only provide a way for the central bank to specify its ceiling for a particular interest rate over a specified future period, but the day-to-day changes in the price of the option also provide a market-based index of the credibility of the particular interest-rate ceiling specified in the options contract. Should the central bank's commitment to low interest rates be questioned in the market, the central bank could read this from the option prices and could attempt to provide a policy response--either with options or other instruments.

Purchasing Foreign Exchange

By purchasing foreign exchange, a central bank could hope to depreciate its currency and spur net demand for domestic goods and services. When interest rates are above zero, unsterilized intervention causes more depreciation than sterilized intervention.[21] This is because an unsterilized intervention lowers the domestic interest rates, whereas a sterilized intervention

[21] In unsterilized intervention, the authorities exchange cash or reserves for securities denominated in foreign currency, with the result that the domestic monetary base changes with the intervention and, normally, domestic interest rates change. In sterilized intervention, the change in the domestic base is offset by a purchase or sale of domestic currency securities and domestic interest rates are normally left unchanged.

does not. However, at the zero bound, the two types of intervention have the same effects because the unsterilized intervention cannot lower the interest rate.

With risk neutrality and current U.S. interest rates fixed at zero, foreign exchange intervention could cause the dollar to depreciate in the current period if (and only if) it caused private agents to expect the dollar to be depreciated more in the future than they expected it to be before the intervention. At issue is whether U.S. authorities could create expectations of a future depreciation by credibly signaling their intentions for the future course of the short-term nominal interest rate. If U.S. authorities sold dollar assets in the current period and used the proceeds to purchase foreign assets, they would stand to gain if the dollar were to depreciate in the future. Observing current foreign exchange purchases by U.S. authorities, market participants might expect the U.S. authorities to lower interest rates in the future to bring about this depreciation. If so, with interest rates in the current period fixed at zero, the dollar must depreciate in the current period in order to maintain interest rate parity. The empirical literature provides only limited support for the existence of such signaling effects and suggests that if they are present at all, they vary from episode to episode and disappear fairly quickly.

Alternatively, foreign exchange purchases could succeed in causing the dollar to depreciate if U.S. and foreign assets are imperfect substitutes because agents are risk averse. In effect, changes in relative supplies of assets would then affect relative returns, and by purchasing foreign exchange, the Federal Reserve would be increasing the supply of dollar-denominated assets relative to foreign assets. However, an extensive empirical literature has almost universally concluded that such relative supply effects have little or no lasting impact on exchange rates.

Purchasing Private-Sector Securities

While using a credible rule to set short-term interest rates, purchasing government bonds, and using options may all help to lower and flatten the Treasury yield curve, the yield curves for private sector securities could remain somewhat elevated. In particular, if short-term Treasury rates are at zero and the economy is floundering, credit risk premiums could be quite high.   If these risk premiums are holding back an economic recovery, the central bank could potentially unlock credit flows and jump start the economy by taking this credit risk onto its balance sheet, for example, through purchases of private sector securities. The key issue for a central bank contemplating such actions, however, is whether it is authorized to and whether it wants to take such private-sector credit risk onto its balance sheet.

The Federal Reserve, for example, faces some important restrictions regarding the type of private-sector securities that it is authorized to purchase. The current statutory authority for open market operations is still strongly influenced by the intent of the original framers of the Federal Reserve Act. One intent of the Federal Reserve Act was to spur the development of the bankers' acceptance market. It was thought that if the Federal Reserve could purchase and sell bankers' acceptances and similar types of securities, this would stimulate the development of private markets for these types of credit instrument. Accordingly, even today, while the Federal Reserve can purchase virtually all types of Treasury and agency securities, it can purchase only certain types of private sector securities---bankers' acceptances and bills of exchange. Accordingly, the Federal Reserve is not authorized to purchase notes, such as corporate bonds and mortgages; nor can it purchase equities or real property such as land or buildings.[22]

Even within the class of bankers' acceptances and bills of exchange, Federal Reserve purchases are limited to those instruments that arise out of transactions in real commerce.[23] By tying Federal Reserve purchases to instruments financing real commerce, it was thought that the money stock would expand and contract in line with real business activity. By this means, there would be enough money and credit to provide for real business needs, but excessive money growth and its inflationary consequences would be avoided.

As mentioned above, a key aspect of the purchase of any asset by a central bank would be whether the central bank can take onto its balance sheet the credit risk inherent in the asset. For open market purchases, there does not seem to be any explicit instruction that the Federal Reserve can not take credit risk onto its balance sheet. The limitation to taking on credit risk would seem to stem from the types of instruments that it can purchase--namely bankers' acceptances and bills of exchange arising out of real commerce. In practice, the Federal Reserve

[22] The private-sector debt instruments that the Federal Reserve can purchase are limited to those eligible for discount, which generally excludes corporate debt and mortgages for example. However, the class of private-sector debt instruments eligible for purchase could be expanded to include corporate bonds, mortgages and other instruments under section 13(3) of the Federal Reserve Act. Under 13(3), if the Board of Governors found there to be "unusual and exigent circumstances" and voted by a majority of at least five governors to authorize lending under 13(3), the Federal Reserve could discount to individuals, partnerships, and corporations "notes, drafts and bills of exchange ....indorsed or otherwise secured to the satisfaction of the Federal Reserve Banks..." This broadening of the class of instruments eligible for discount would correspondingly broaden the class eligible for purchase.

[23] Unless the purchases were done under section 13(3) of the Federal Reserve Act.

has stipulated that, as stated by Woelfel (1994), "a bill of exchange is not eligible for purchase until a satisfactory statement has been furnished of the financial condition on one or more of the parties." This condition, if not changed subsequently by the Federal Reserve, would seem to limit the private-sector credit risk the Federal Reserve would be taking onto its balance sheet by way of open market operations.

Discount-Window Loans

A central bank can also attempt to spur private aggregate demand by extending loans to depositories, other financial intermediaries, or firms and households. By making the loan, the central bank turns an asset that may be illiquid for the lender into a liquid asset. This may be particularly helpful in spurring aggregate demand should the financial sector be under stress and in need of liquefying its assets.

In the United States, the Federal Reserve currently lends only to depository institutions. But in contrast to the limited type of securities the Federal Reserve can purchase, it can accept as the security for a loan virtually any security that the Federal Reserve Banks themselves deem acceptable. And in fact, the Federal Reserve accepts mortgages covering one- to four-family residences; state and local government securities; and business, consumer, and other notes. These notes can be open market securities such as corporate bonds and commercial paper or can be commercial and industrial loans extended by banks, for example.

Perhaps the most important limitation on Federal Reserve lending activity regards the credit risk associated with the security used for collateral. It has generally been seen as the intent of Congress that, in the event of a default on the collateral, the Federal Reserve should look to the depository as a source of payment. Therefore, the credit risk of the underlying security stays off the balance sheet of the Federal Reserve and in the private sector. In a situation in which nominal rates are zero and the economy is in adverse straights, credit-risk premiums could be high and holding back aggregate demand.

The Federal Reserve also has the authority to make loans directly to individuals, partnerships, and corporations (IPCs). Use of this authority is limited to cases of "unusual and exigent" circumstances and for cases in which credit is not available from other sources. Also, the discounted securities must be "endorsed or otherwise secured to the satisfaction of the Federal Reserve Bank". As interpreted by Hackley (1973), this requirement seems to limit the credit risk that the Federal Reserve could take onto its balance sheet:

> "In any case, it seems clear that it was the intent of the Congress that loans should be made only to credit-worthy borrowers; in other words, the Reserve Bank should be repaid in due course, either by the borrower or by resort to security or endorsement of a third party"

Again, if the Federal Reserve cannot take credit risk onto its balance sheet, there may arise times in which elevated credit-risk premiums are holding down aggregate demand and the Federal Reserve would itself lack a tool to lower these risk premiums.[24]

Printing Money to Induce Wealth Effects

When interest rates are positive and policy actions lower them, one channel through which aggregate demand is raised is the wealth effect generated by higher asset prices. But if interest rates are at the zero bound, then there are no wealth effects from the open market operations in these assets. This leaves wealth effects operative only if the central bank can directly engineer increases in wealth either by purchasing assets at above market values or by "printing" money and somehow distributing it to the public as a transfer payment.

Regarding the purchase of assets at above market values, this would appear to be problematic, at least on the political level if not on legal grounds. Deciding which types of assets to purchase at above market value would entail distributing wealth to some members of the public and not others based solely on their asset holdings. However, on strictly legal grounds it would seem possible for the Federal Reserve to purchase assets at above-market prices even if this results in negative interest rates on those purchased assets.

Printing money and distributing it to the public probably is not legal under the Federal Reserve Act. Under the act, after all expenses have been paid and the stockholders have received a dividend of 6 percent, the net earnings of the Federal Reserve must be put into a surplus account. It appears that direct transfers from the surplus account are not authorized by the Act. Even if allowed, the printing of money would entail issues of fairness and equity: would checks be mailed out to individuals, or would money be given to deposit holders through depository institutions? Questions affecting the distribution of wealth may best be left to the political process.

[24] The Federal Reserve may not be in the best situation to deal with elevated risk premiums directly. Any social benefits to having the Federal Reserve lending directly to IPCs and take on credit risk would have to be weighed against the potential costs of placing the Federal Reserve squarely in process of evaluating credit applications and allocating credit.

The printing and distribution of money could have to be achieved in conjunction with the political process by means of a money financed reduction in income taxes. But any such action can be seen as composed of two components--a tax cut financed by new issuance of Treasury bills and an open market purchase of the bills. Since the later effects are likely to have little effect at the zero bound, the total effect would come from the fiscal stimulus. Of course, if the fiscal stimulus were large enough to raise the nominal interest rate above zero, then standard open market operations would regain their stimulative impact.

5. Monetary policy and price stability

A framework for understanding monetary policy

The theory and practice of monetary policy in a regime of price stability has much in common with the theory and practice of monetary policy at low or moderate inflation, and we begin by considering how our framework for characterizing and understanding monetary policy (whether at moderate or low inflation) has evolved over the last decade. The Barro-Gordon (1983) view in which authorities have an incentive to inflate unexpectedly to pump up the economy has been supplemented by models of independent central bankers with a “taste” for price stability, such as Rogoff (1985).

And at least in the US, the focus has shifted from viewing a monetary aggregate as the authorities’ control variable, with estimated money demand equations to guide policy, to the use of policy reaction functions, or “rules”, linking the short term interest rate directly to inflation and output targets. This concept provides a useful framework for modeling and understanding monetary policy.

To illustrate, consider the following regression equation reported in Levin, Wieland, and Williams (1998):

(1) $$\boldsymbol{r}_t = -0.0042 + 0.795\,\mathbf{r}_{t-1} + 0.635\,\pi_t + 1.171\,\boldsymbol{y}_t - 0.967\,\boldsymbol{y}_{t-1}$$

where $\boldsymbol{r}_t$ is the federal funds rate, π_t is the four-quarter moving average of the inflation rate, and $\boldsymbol{y}_t$ is the current output gap (the percentage difference between potential and actual GDP). This equation, which was estimated using quarterly U.S. data over the period from 1980 to 1996, suggests that the Federal Reserve tended, as one might expect, to raise the funds rate in response to increases in inflation and in the excess of actual over potential output. There are no explicit terms for the target values of inflation and the equilibrium real interest rate in this equation–these values are implicitly assumed to be fixed and are subsumed in the regression's constant term. The coefficient on the lagged funds rate indicates a fairly high degree of interest rate smoothing, while the lagged term in the output gap suggests that the Fed responded to the growth of output as well as to the level.

In reality, the process through which the Federal Open Market Committee reaches a decision to raise or lower the funds rate in a given period is substantially more complex than this estimated equation suggests. However, such a characterization may for many purposes be a useful summary of the underlying decision-making process, and in any event captures some of the key elements of that process.[25]

The optimal form for a policy rule depends on the objectives of the monetary authorities, which are here assumed to be to minimize (some combination of) the variability of inflation, output, and the interest rate itself. It also depends on the structural relationships in the economy, and different estimated models will imply different estimated optimal policy rules for given objectives. Optimal rules may include many more variables, and more lagged terms, than the equation given above. Obviously, in order to implement an optimal rule, the "true" structural model of the economy must be known. Since this model is not in fact known with certainty, it is of interest to identify policy rules that perform well for a variety of models.

Taylor (1993) and Henderson and McKibbin (1993) both propose simple rules of this form:

(2) $$\boldsymbol{r}_t = (\mathbf{r}^* + \pi_t) + \alpha\,(\pi_t - \pi^*) + \beta\,\boldsymbol{y}_t$$

where $\mathbf{r}^*$ is the equilibrium real interest rate and π^* is the target for the inflation rate, both assumed to be constant. (The target for the output gap, $\boldsymbol{y}_t$, is assumed to be zero.) These authors argue that rules of this type not only characterize actual policy fairly well, but are likely to perform well in the face of a variety of shocks to the economy.[26] Levin, Wieland, and Williams examine this hypothesis using four different macroeconometric models of the U.S. economy. They confirm that simple rules are indeed robust across model structure, although they find that

[25] Among other advantages, reaction functions of this type allow model-builders to incorporate policy responses explicitly in their models and maintain at least a degree of consistency between government policy and private sector behavior. This approach mitigates to some extent the effects of the well-known Lucas (1973) critique.

[26] The performance of a rule is often measured by computing the variability of output and inflation using the rule, assuming a particular model structure. In some cases this computation can be performed analytically; in others, stochastic or "Monte Carlo" simulations are used to estimate the variances in question.

rules that incorporate more interest rate smoothing generally perform better than do the simple Taylor and Henderson-McKibbin rules.

Monetary policy and price stability

Monetary policy at low or zero inflation rates faces some special problems that distinguish it from policy in regimes of higher inflation.[27]

One practical question is whether to set a target for the inflation rate or the path of the price level. The difference is essentially whether the authorities attempt to offset periods when inflation is above the long run target with periods when it is below target, or whether they merely attempt to bring the inflation rate back to the desired long run value. In the case of zero inflation, of course, a price level target would require periods of actual deflation in order to offset any inflationary shocks.

Credibility and transparency are always important in formulating and implementing monetary policy because of their effect on interest rates and wage and price formation through expectations of future policy. These factors are no less vital at near-zero inflation rates because it is particularly important to place a floor under inflation expectations to avoid a deflationary spiral in the event of a negative shock. Krugman (1998) makes this point in connection with the current situation in Japan, using a simple model to show that if the Japanese authorities could credibly commit to raising inflation in the future, that would lower current long-term real rates and stimulate the economy even without lowering current short rates. Of course, for such a commitment to be credible, the authorities must have some feasible way of raising future inflation. One possibility is that if nominal long-term rates are above zero and market expectations are rational, then expected short rates must be above zero at some point in the future. By announcing a (credible and transparent) policy to lower those future rates, the authorities can affect long rates in the current period.

The lower bound on nominal rates doubly complicates the policy-making problem – monetary policy instruments become less effective at the same time the economy becomes less stable.[28] Perhaps the simplest policy response is to choose a target inflation rate that is somewhat

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[27] Again, we neglect the question of policies used to get to a regime of price stability. Some countries have successfully used target ranges and central bank "contracts" to lower inflation (Canada, New Zealand), some have used a combination of fiscal and monetary policy to meet announced goals (EMU members), and others have pursued a more opportunistic approach to lowering inflation (the United States).

[28] Indeed, in order to solve a macroeconometric model in the neighborhood of the zero bound on interest rates it may

above zero. As this target is incorporated into market expectations, the short term nominal interest rate will rise as well, giving the authorities extra room to cut short rates as needed. As discussed in the previous section, several recent papers by FRB staff economists have studied the effectiveness of different policy rules in the neighborhood of the zero bound. These results suggest that a target inflation rate of 2 percent is high enough to greatly reduce the effect of the zero bound on policy in all but the most extreme shocks.[29]

Using simple rules of the Taylor/Henderson-McKibbin form, these papers demonstrate that more aggressive policies that respond to shocks with larger changes in interest rates may be helpful. While with these policies interest rates will hit the zero bound more often, because they respond more, the stronger response tends to bring the economy back to the baseline faster. For example, Taylor proposed parameter values of $\alpha = 0.5$, $\beta = 0.5$ for equation (2), meaning that the Fed is assumed to raise the funds rate by 50 basis points in response to an increase in the contemporaneous inflation rate of 100 basis points, over and above the increase of 100 basis points needed to maintain a constant real interest rate.[30] Henderson and McKibbin proposed values of $\alpha = 1.0$, $\beta = 2.0$, implying a substantially stronger interest rate response to a deviation of inflation or the output gap from their target values. Orphanides and Wieland (1998) use stochastic simulations of their model to show that the Henderson-McKibbin rule succeeds in keeping inflation and output closer to their targets, on average, despite the presence of the zero bound. This is because the stronger response "cuts off" recessions faster, tending to prevent the economy from moving into prolonged recession in which interest rate cuts would be ineffective.

An extension of this point is that asymmetric rules that provide a stronger response to negative shocks may be even more efficient in meeting policy objectives. In the face of inflationary pressures the authorities can raise interest rates smoothly in response, raising rates as much as (but no more than) desired. Confronted with a negative, deflationary shock, the response can be more aggressive, up to the limit imposed by the zero bound. Suppose that

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be necessary to assume that fiscal policy responds to negative shocks in order to stabilize the economy. See Orphanides and Wieland (1998).

[29] In view of the upward bias in measured price indexes, one might assume that the authorities would target a positive inflation rate in any event. However, this inflation would only be passed on to nominal rates if market participants used the biased price index in calculating their own purchasing power, which might or might not be the case.

[30] This increase is reflected in the first term of equation (2), $(\mathbf{r}^* + \pi_t)$.

absent considerations of the zero bound, the optimal parameters for a policy rule of this type, taking into account the authorities' preferences for trading off the variability of inflation, output, and the interest rate itself, were $\alpha = 0.5$, $\beta = 0.5$. At high target inflation rates, the authorities can use this policy rule without regard to the zero bound. At low inflation targets, and therefore low nominal interest rates, the zero bound may bind, and potentially prevent the authorities from stabilizing the economy in the face of large negative shocks. In this case it might be desirable to use, say, the Henderson-McKibbin parameters of $\alpha = 1.0$, $\beta = 2.0$ when output or inflation fall below target, in order to return to baseline as quickly as possible even at the cost of larger interest rate changes. In the face of a positive shock to output, however, the authorities could respond more moderately, with the Taylor parameters, to limit the variation in interest rates somewhat.

Despite the effectiveness of rules of this type, it remains the case that large negative shocks to demand can push the economy into ongoing deflation in which conventional interest rate policy becomes ineffective. Such a case may require use of alternative policy instruments such as those described earlier, or indeed they may require a more aggressive fiscal intervention in order to stabilize the price level.

6. Conclusions

The experience of the United States during the Great Depression and of Japan at the present time demonstrates the potential for stable (or falling) prices to be associated with near-zero nominal interest rates and, in these cases, with falling real output. In two other cases, the United States in the 1950's and at present, a low and stable inflation rate has been associated with steady real growth and positive nominal rates. While the zero lower bound on nominal rates is potentially a very serious problem for stabilization policy, price stability is often associated with a very prosperous economic environment.

In setting inflation objectives in a regime of near price stability, the authorities must consider a number of factors whose empirical magnitudes may well be country specific. The existence of significant measurement bias in published price indexes suggests that a small positive target for measured inflation corresponds to true price stability, at least in the United States. A low but positive rate of expected inflation may help real wages adjust appropriately and may also reduce the risk that policy will be constrained by the zero lower bound on nominal interest rates. However, the observed negative correlation between inflation and productivity growth may imply that, relative to low inflation, price stability may raise productivity growth and, by raising real interest rates, make the zero bound a less pressing problem.

The zero lower bound on nominal interest rates is a potentially serious problem, since it means recessions may be longer on average and the risk of a downward deflationary spiral may increase. Empirical analysis using stochastic simulations of macro econometric models has confirmed the significance of these effects for the United States. Alternative policies, such as open market operations in government bonds, or writing options on future short rates, may be effective at the zero lower bound, but ultimately fiscal policy action may be needed to bring the economy out of a deflationary spiral. Historical episodes suggest that a healthy banking sector may play a key role in avoiding problems due to the zero lower bound.

Policy rules, or reaction functions, provide a useful framework for analyzing monetary policy. U.S. policy over the past two decades can be summarized by an estimated equation relating interest rate changes to changes in inflation and the output gap. A stronger response to inflation or output shocks, all else being equal, may help avoid zero lower bound problems by moving the economy more quickly back to baseline. An asymmetric rule that responds more aggressively to deflationary impulses near the zero lower bound may also be appropriate. The choice of policy rule depends on the empirical importance of the factors considered earlier, which may differ from country to country.

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